Aug. 28, 1934. H. W. DUDLEY 1,971,679

TRANSMISSION CONTROL CIRCUITS

Filed Jan. 30, 1931 2 Sheets-Sheet 1

FIG. 1.

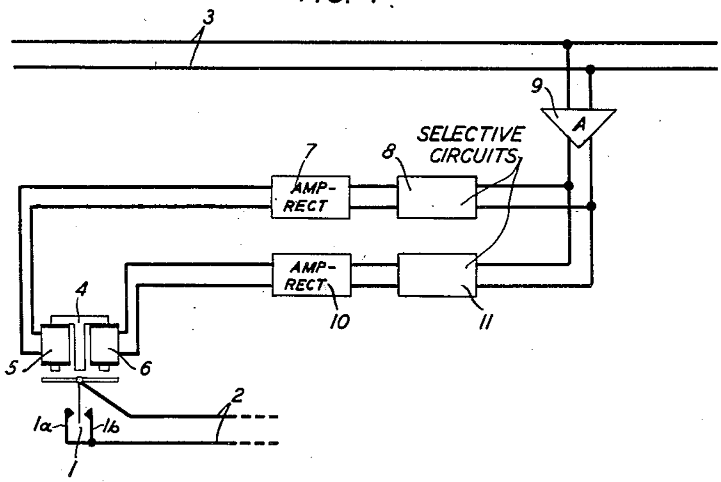

FIG. 2

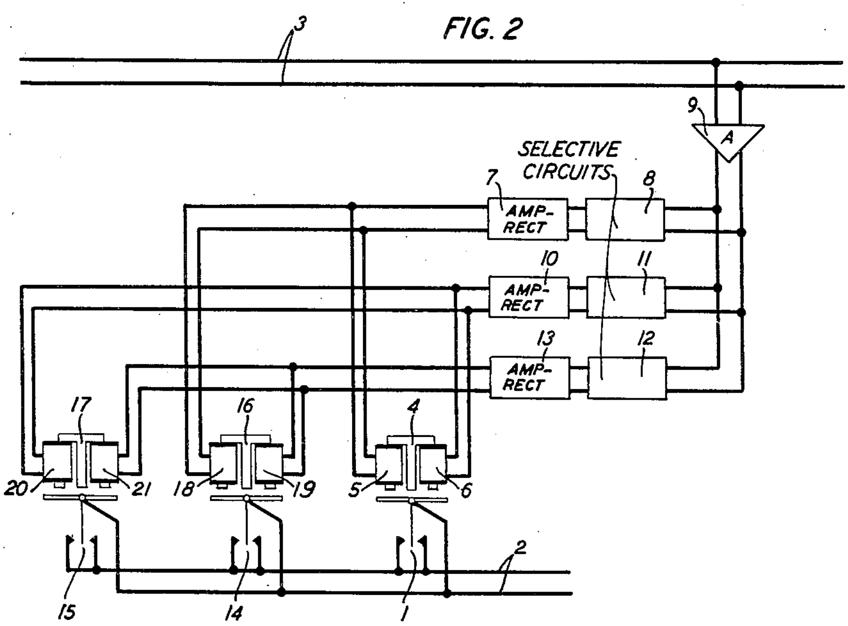

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FIG. 3

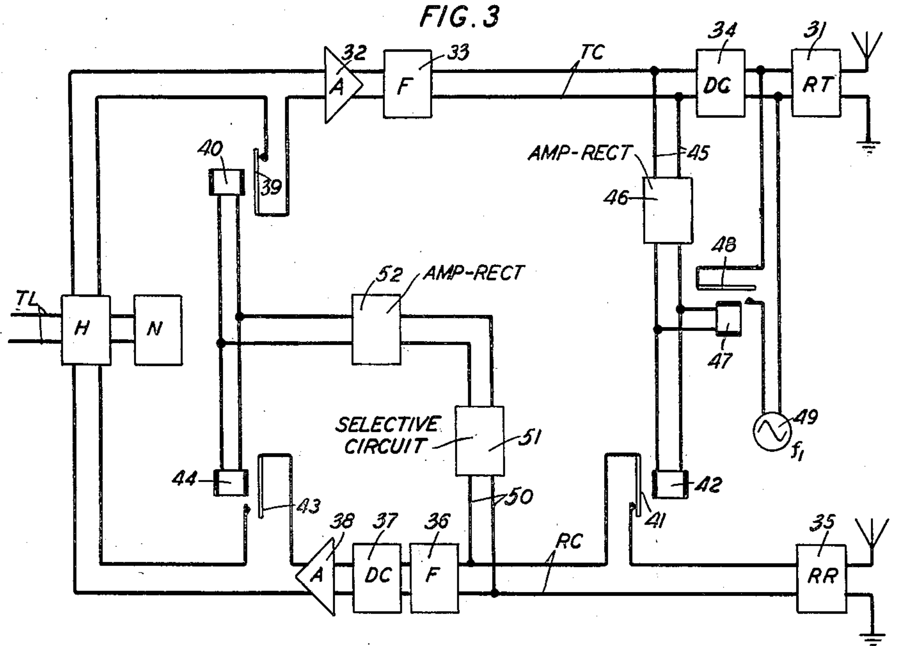
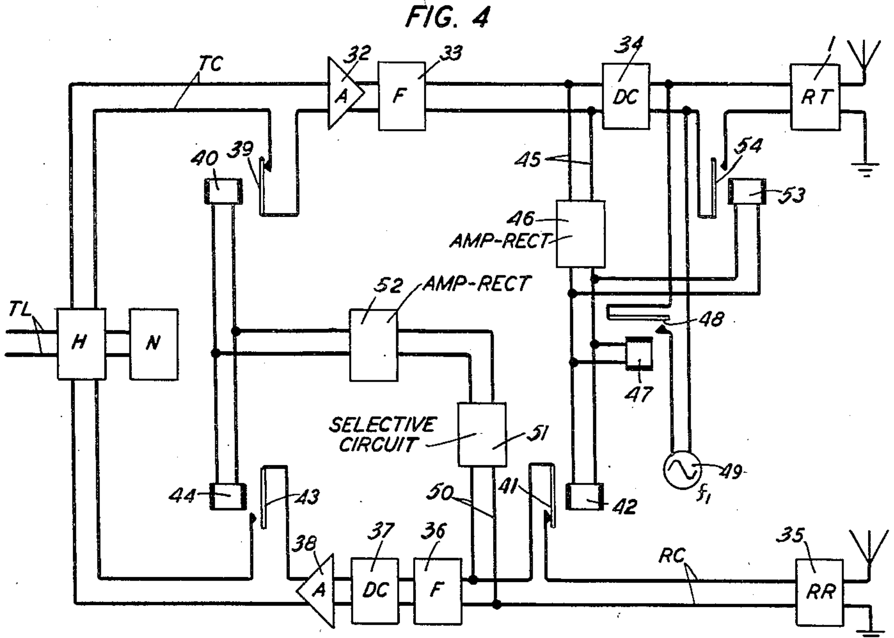


FIG. 4



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TRANSMISSION CONTROL CIRCUITS

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Application January 30, 1931, Serial No. 512,246

2 Claims. (Cl. 178—44)

This invention relates to transmission control in signaling systems and particularly to circuits for reducing the effects of interfering waves in such systems.

An object of the invention is to discriminate between electrical waves of different characteristics, for example, between useful signals and interfering noise waves.

Another object is to improve the operation of signal-controlled devices for suppressing echoes and preventing singing in two-way signaling systems subject to interfering waves, such as static or line noise.

The invention in a broad aspect is a system for discriminating between speech waves or waves having energy characteristics similar to speech waves, and waves which over a definite frequency range have a substantially constant energy level, such as static or so-called line noise. A preferred embodiment of the invention may be used in connection with a two-way signaling system employing wave-controlled, anti-singing and echo suppression devices at the terminals thereof. Discrimination between signals and interfering waves in such a system is obtained in part by utilizing, for selectively controlling certain of these devices at each terminal, a control wave preferably of a single frequency and fixed magnitude at one point in the system, transmitted from the other terminal along with the signals and under the control thereof. At the receiving station, the received control wave is eliminated from the signal receiving circuit to prevent it being heard by the listener, and at the transmitting station, the signal frequencies corresponding to those of the control waves are eliminated in the signal transmitting path so as to prevent false operation of the local and distant receiving control devices by them.

Further discrimination against static and noise is obtained in the system of the invention by the use therein of specially designed circuits for preventing operation of the wave-controlled anti-singing and echo suppression devices by static or noise interference without decreasing the sensitivity of these devices as regards operation by the control waves or other signals. This circuit is designed to discriminate between the signal waves and the interfering waves, such as static or line noise, on the basis of the difference in the amount of power contained in small adjacent frequency bands of the two types of waves.

In the case of static and similar interference energy, the power in small adjacent frequency bands is substantially the same at any instant, while in the case of speech waves or waves produced by a generator of a single frequency, such as the control waves employed in the two-way signaling system of the invention, a band width slightly less than that of the fundamental may or may not include a harmonic containing a substantially greater amount of power. These distinguishing differences are made use of in the discriminating circuit of the invention, which, specifically described, comprises one or more differentially wound relays, the windings of which are connected with the transmission path carrying the speech or control waves and the static or other noise waves through selective circuits, such as filters, each selecting a different small frequency band of the combined waves. The static or noise components of adjacent selected bands having substantially the same amount of power are balanced out in the differential windings of the relay, while the relay will be operated by the difference power of the speech or other signal components in the same selected bands, if only one contains a harmonic. Of course, if only two selective circuits are employed, and both the frequency bands selected thereby contain a harmonic of the same magnitude, the speech or control wave components will be balanced out also. To get around this difficulty, it may be desirable to employ more than two selective circuits to insure that the speech or control wave power is not present in equal magnitude in all of the selected bands. Three selective circuits should be sufficient in which case three differential relays, the operation of any one of which will give the required control of the transmission circuits, would be employed.

The invention will be better understood from the following detailed description thereof when read in connection with the accompanying drawings, in which Fig. 1 shows diagrammatically a discriminating circuit in accordance with the invention in its simplest form:

Fig. 2 shows diagrammatically a more complicated form of the discriminating circuit of the invention suitable for preventing false operation of the signal-controlled switching circuits by noise in a two-way submarine telephone cable or a radio telephone circuit; and

Figs. 3 and 4 show diagrammatically different forms of a radio telephone terminal circuit embodying the circuits of the invention.

The discriminating circuit of Fig. 1 comprises a normally open switch 1, which when closed controls over the circuit 2, the transmission efficiency of an electrical circuit (not shown) or the operation of apparatus therein in a desired manner. It is desired that the switch 1 be closed only in response to the signals, for example, speech signals, transmitted over the transmission path 3, which path is also subject to interfering waves such as line noise or static. Switch 1 is controlled by the mechanical relay 4, which has two differentially wound windings 5 and 6. When the energizing current in the winding 5 predominates over that in the winding 6, the relay armature which is conductively connected to one side of the circuit 2 makes contact with one contact 1*a* of switch 1, and when the energizing current in the winding 6 of relay 4 predominates over that in the winding 5, the relay armature will make contact with the contact 1*b* of the switch 1. As 1*a* and 1*b* are each connected to the other side of the circuit 2, the switch 1 is closed to connect the two sides of the circuit 2 together when the energizing current in either winding of relay 4 predominates over that in the other.

The winding 5 of the relay 4 is connected to the output of the wave-controlled, relay-controlling device 7, the input of which is connected through the selective circuit 8 to the output of the one-way wave amplifying device 9 the input of which is connected across the line 3 carrying the signals and subject to the interfering waves. Similarly, the opposing winding 6 of the relay 4 is connected so as to be supplied with energizing current from the output of the wave-controlled, relay-controlling device 10 the input of which is connected through the selective circuit 11 also to the output of the amplifying device 9.

The wave-controlled, relay-controlling devices 7 and 10 may be vacuum tube amplifier-rectifier devices of the type well known in the art or any other device which will respond to alternating current waves impressed upon their inputs to produce rectified current of proportional amplitudes in their outputs. The devices 7 and 10 should have the same amplification factor.

The selective circuits 8 and 11 may be resonant circuits of the type well known in the art, each tuned to a selected different frequency within the frequency range of the waves impressed upon its input, so as to transmit with little attenuation, the resonant and neighboring frequencies in the impressed waves while producing appreciable attenuation in other frequencies of the impressed waves. Alternatively, the selective circuits 8 and 11 may be band-pass filters of well known type, for example, such as disclosed in the United States patents to Campbell, Nos. 1,227,113 and 1,227,114, issued May 22, 1917, in which case each filter is designed to transmit with little attenuation a different, narrow sub-band of frequencies within the frequency range of the waves impressed upon its input while producing appreciable attenuation in the impressed frequencies outside the range of the selected sub-band. The design of the selective circuits is such that the frequency sub-bands transmitted with little attenuation are closely adjacent and of such small width that the amount of energy in each due to noise or static is essentially the same at any instant.

The circuit of Fig. 1 operates as follows: The signals transmitted over the transmission circuit 3 and the accompanying noise waves are applied simultaneously to the input of the amplifying device 9 and are amplified thereby. The amplified, combined waves in the output of the amplifying device 9 divide between the input of the selective circuit 8 and the input of the selective circuit 11. The selective circuit 8 selects from the impressed waves a frequency band of very small width compared to the total frequency range of the waves in the output of the device 9, and the selective circuit 11 selects from the impressed waves an adjacent frequency sub-band of the same width.

The selected sub-band in the output of the selective circuit 8 is impressed on the input of the device 7, which will produce in its output, rectified currents of proportional amplitudes which are supplied as energizing current to the winding 5 of the relay 4. Similarly, the small selected sub-band in the output of the selective circuit 11 is impressed on the input of the device 10 which will produce in its output circuit, rectified currents of proportional amplitudes which are supplied as energizing current to the winding 6 of the relay 4. The selective circuits 8 and 11 being designed so that the two frequency bands transmitted thereby are closely adjacent in the frequency scale and of sufficiently small width, the amount of power due to noise or static in the selected bands supplied to the windings 5 and 6 of relay 4 is approximately the same and, therefore, the noise or static components are effectively balanced out in the relay winding. However, it is quite probable that the amount of power due to speech energy in the band in the output of one of the rectifying devices 7 or 10 may be considerably larger than that in the band in the output of the other device due to the presence therein of one or more speech harmonics containing an appreciable amount of power and the absence of a harmonic of equal magnitude in the other band. If that is the case, the magnitude of the energizing current supplied to one of the windings 5 or 6 of the relay 4 will be sufficiently greater than that supplied to the other winding to cause operation of the relay to attract its armature so that it makes contact with either the contact 1*a* or the contact 1*b* of the switch 1 depending upon which winding of the relay has the largest energizing current, causing the circuit 2 to be short-circuited and thus controlling the transmission characteristics of the circuit associated with circuit 2 or the apparatus therein in accordance with the speech waves transmitted over the circuit 3.

Of course, there is a remote possibility that the two bands of waves selected by selective circuits 8 and 11 may each contain a harmonic of speech of the same magnitude so that the speech will also be effectively balanced out in the relay 4 in the same manner as the noise waves. This remote possibility may be prevented by modifying the circuit of Fig. 1 as shown in Fig. 2.

As indicated in Fig. 2, an additional selective circuit 12 is connected to the output of the amplifier 9 in parallel with the selective circuits 8 and 11. The selective circuit 12, which may be a band filter, is designed to transmit with little attenuation from the impressed waves in the output of the amplifying device 9, a frequency band closely adjacent to that of the selective circuit 8 or 11 and of the same width while producing appreciable attenuation in the impressed frequencies outside the range of that selected sub-band. A wave-controlled, relay-controlling device 13, similar to the devices 7 and 10, is connected to the output of the selective circuit 12 and is arranged to amplify and rectify the selected sub-band. The devices 7, 10 and 13 are designed to have the same amplification factor.

Whereas, in the system of Fig. 1, a single switch 1 controlled by a single differentially wound relay 4, was utilized for connecting the short-circuiting path across the circuit 2, in the modified system of Fig. 2, in addition to the switch 1, two other switches 14 and 15 controlled respectively by operation of the differential wound relays 16 and 17 are each adapted to produce a short circuit across the circuit 2 in parallel with that produced by operation of the switch 1. One of the differential windings 18 of the switch 16 is connected to the output of the device 7 so as to be supplied with energizing current from the output thereof. The other differential winding 19 of relay 16 is connected so as to be supplied with energizing current from the output of the device 13. One winding 20 of the relay 17 is connected to the device 10 so as to be supplied with energizing current from the output thereof. The other differential winding 21 of the relay 17 is connected to the device 13 so as to be supplied with energizing current from the output thereof. The differential windings 5 and 6 of the relay 4 are connected so as to be supplied with energizing current from the output of the device 7 and the device 10, respectively, as in the circuit of Fig. 1.

It will be seen that the connections are such that the rectified current in the output of the device 7, having a frequency range corresponding to that of the narrow frequency band selected by the selective circuit 8, will be divided between one winding 5 of relay 4 and one winding 18 of relay 16; that the rectified current in the output of the device 10, having a frequency range corresponding to that of the different narrow frequency band selected by the selective circuit 11, will be divided between the other differential winding 6 of relay 4 and the winding 20 of relay 17; and that the rectified current in the output of the device 13, having a frequency range corresponding to that of the different narrow sub-band selected by the selective circuit 12, will be divided between the other winding 19 of relay 16 and the other winding 21 of relay 17.

As the frequency sub-bands selected by selective circuits 8, 11 and 12 have the same width, and the selected sub-bands are closely adjacent, the power in each is essentially the same at any instant. Therefore, the portion of the energizing current due to the noise components, supplied to each winding of each relay is approximately the same. As the two windings of each relay are wound in opposition, it is seen that the noise components are effectively balanced out in the windings of each relay, and the operation of the switches 1, 14 and 15 is independent of the noise.

It is almost certain that one or more speech harmonics of appreciable power will be present in one of the frequency sub-bands selected by the selective circuits 8, 11 or 12, and that one of the other two bands will not contain a speech harmonic of equal magnitude to that in the first selected band. It is apparent, therefore, that the magnitude of the energizing current in the two windings of at least one of the relays 4, 16 and 17 will be sufficiently different to cause the armature of that relay to be thrown to one or the other of the contacts of the switch controlled thereby so as to close at least one of the short-circuiting paths across the circuit 2. The transmission efficiency of the associated transmission circuit or the operation of the apparatus therein will be controlled, therefore, by the signals transmitted over the transmission path 3. If the three selective circuits 8, 11 and 12 are properly designed, it is very improbable that the speech power will be present in equal magnitude in all of the selective circuits. However, this possibility may be made still more remote by employing a greater number of selective circuits and a corresponding number of relays and switches connected in a manner similar to that shown in the system of Fig. 2.

Fig. 3 shows the west terminal circuit of a radio telephone system. It comprises a transmitting circuit TC and a receiving circuit RC each associated in energy transmitting relation with a two-way telephone circuit TL and in conjugate relation with each other by means of the hybrid coil H and associated balanced network N in well known manner. Connected in the transmitting circuit TC between the hybrid coil H and the radio transmitter 31 including a transmitting antenna, is the one-way amplifying device 32, the filter 33 and the delay circuit 34. Connected in the receiving circuits RC between the radio receiver 35 including a receiving antenna and the hybrid coil H is the filter 36, the delay circuit 37 and the one-way amplifying device 38.

In the transmitting circuit TC between the hybrid coil H and the input of the one-way amplifying device 32 is a normally closed switch 39 adapted to be opened by operation of the mechanical relay 40. In the receiving circuit RC between the radio receiver 5 and the input of the filter 36 is a normally closed switch 41 adapted to be opened by operation of the mechanical relay 42. In the receiving circuit RC between the hybrid coil H and the output of the one-way amplifying device 38 is a normally open switch 43 adapted to be closed by operation of the mechanical relay 44.

Connected across the transmitting circuit TC between the delay circuit 34 and the filter 33 is a control circuit 45 comprising the wave-controlled, relay-controlling device 46 and the windings of the mechanical relays 47 and 42 connected in parallel to the output of the device 46. A normally open switch 48 is adapted to be closed by operation of the relay 47 to connect the generator 49, of a control wave of the frequencies f_1 which are preferably outside the speech frequency range, across the transmitting circuit TC between the delay circuit 34 and the radio transmitter 31.

Connected across the receiving circuit RC between the normally closed switch 41 therein and the filter 36 is a control circuit 50 including the selective circuit 51, the wave-controlled, relay-controlling device 52, and the windings of the mechanical relays 40 and 44 connected in parallel to the output of the device 52.

The east terminal circuit (not shown) of the radio telephone system may be assumed to be identical with that at the west terminal circuit except perhaps for the value of the control wave frequencies, f_2, generated by the control wave generator there at the two stations, and the transmission frequency range of the filter 36 and the corresponding filter at the east terminal which depends upon the values of f_2 and f_1, respectively. The control wave frequencies f_1 and f_2 are both preferably outside the speech frequency range. They may have the same or different values.

The selective circuit 51 in the control circuit 50 at the west terminal station may be a resonant circuit of the type well known in the art, tuned to a frequency corresponding to the mid-frequency of the band f_2 generated by the control wave generator at the east terminal station, so as to transmit with little attenuation, the resonant frequency and neighboring frequencies in the impressed wave while producing appreciable attenuation in other frequencies of the impressed waves including those in the speech frequency range. Alternatively, the selective circuit 51 may be a band-pass filter of well known type, for example, such as disclosed in United States patents to Campbell, Nos. 1,227,113 and 1,227,114, issued May 22, 1917, in which case the filter is designed to transmit with little attenuation the band of frequencies f_2, while producing appreciable attenuation at frequencies outside that band including the frequencies within the speech frequency range. The selective circuit at the east terminal station corresponding to the circuit 51 at the west terminal station may have a design similar to that of the latter circuit except that it selects a band of frequencies f_1 corresponding to that generated by the generator 49 at the west terminal station.

The filter 36 in the receiving circuit at the west terminal station may be a band-pass filter designed to suppress the frequencies f_2 while transmitting efficiently the speech frequencies. The filter in the receiving circuit at the east terminal station corresponding to filter 36 at the west terminal station is also a band-pass filter but designed to suppress the frequencies f_1 while transmitting efficiently the speech wave frequencies. The filter 33 in the transmitting circuit at the west terminal station and the corresponding filter in the transmitting circuit at the east terminal station are also band-pass filters both designed to suppress the frequencies f_1 and f_2 while transmitting efficiently other frequencies.

The delay circuits 34 and 37 may be of any type which will produce a delay of the required amount, which will be specified below, in the transmission of alternating current waves, such as speech waves, therethrough. For example, each may be a low-pass filter, such as disclosed in the Campbell patents mentioned above, or a network such as disclosed for a similar purpose in the United States patent to Arnold, No. 1,565,302, issued December 15, 1925.

The operation of the system having terminal circuits corresponding to that of Fig. 3 will now be described.

The speech waves received over the line TL are impressed by the hybrid coil H upon the input of the transmitting circuit TC and amplified by the amplifying device 32 therein. The amplified waves are transmitted through the filter 33 which will effectively suppress therefrom frequencies corresponding to f_1 and f_2 generated by the control wave generators at the west and east terminal stations respectively. The passed waves will divide between the input of the delay circuit 34 in the transmitting circuit TC and the input of the control circuit 45. The portion diverted into the control circuit 45 will operate the wave-controlled, relay-controlling device 46 therein causing the windings of relays 42 and 47 in its output to be energized. Relay 42 then operates to open the normally closed switch 41 in the receiving circuit RC making that circuit inoperative to transmit waves from the radio receiver 35 to the filter 36 and to the input of the control circuit 50. Relay 47 operates simultaneously with relay 42 to close the normally open switch 48 so as to connect the generator 49 to the input of the radio transmitter 1 causing the control waves of frequencies f_1 to be transmitted to the transmission medium. Meanwhile, the main portion of the speech waves in the transmitting circuit TC have been delayed in transmission to the radio transmitter 31 by the delay circuit 34. The delay circuit 34 is designed to introduce sufficient delay in the transmission of the speech waves to insure that they are not impressed upon the radio transmitter 31 before the control waves f_1 are transmitted thereto from generator 47. The control waves of frequencies f_1 and the speech are then impressed by the transmitting antenna of the radio transmitter 31 on the ether over which they are transmitted to the east terminal station.

The operation at the east terminal of the system will be described by reference to the corresponding receiving circuit at the west terminal station shown. That the apparatus to be referred to is that of the east terminal station will be indicated by designating the apparatus thereat with the same characters as used for designating the corresponding apparatus at the west terminal but followed by a prime (′) mark.

The control wave f_1 and the speech wave transmitted by the radio transmitter at the west terminal upon arrival at the east terminal station will be picked up by the antenna of the radio receiver 35′ thereat and then will be transmitted over the receiving circuit RC′. The combined speech and control waves divide between the input of the control circuit 50′ and the input of the filter 36′ in the receiving circuit RC′. The control waves f_1 are selected by the selective circuit 51′ in the control circuit 50′ and impressed upon the wave-controlled, relay-controlling device 52′ causing its operation to energize the windings of relays 40′ and 44′ in its output. Relay 40′ will operate to open the switch 39′ in the input of the transmitting circuit TC′ at the east terminal station thereby making that circuit inoperative to transmit from that time speech waves from the circuit TL′ to the input of the amplifying device 32′. Relay 44′ will operate simultaneously with relay 40′ to close the normally open switch 43′ in receiving circuit RC′, thereby making that circuit operative to transmit waves from the output of the amplifying device 38′ therein to the circuit TL′ through the hybrid coil H′.

As the filter 36′ in the receiving circuit RC′ is designed to suppress frequencies corresponding to the control wave frequencies f_1, only the speech waves will be transmitted therethrough, and through the delay circuit 37′ to the input of the amplifying device 8′. The delay circuit 37′ is designed to produce just sufficient delay in the speech waves transmitted therethrough to insure that the switch 39′ has been closed under control of the control waves f_1 before the speech waves arrive thereat in the receiving circuit RC′. The amplified speech waves in the output of the amplifying device 38′, the normally open switch 43′ having been previously closed by operation of the relay 44′ in response to the control wave f_1, will be transmitted to the circuit TL′ through the hybrid coil H′.

The relays 40 and 44 should be designed to have sufficient hangover in their action, for example, by making them slow-to-release, to maintain them operated to hold switch 39 open and switch 43 closed, respectively, for a time after the control device 52 releases due to a cessation in the supply of speech waves transmitted into control circuit 50, sufficient to prevent loss of part of the speech or false operation of the transmitting control device. The corresponding relays at the east terminal station should be similarly designed.

From the above description, it is apparent that by the design of the filter 33 in the transmitting circuit TC at the west terminal station and the corresponding filter at the east terminal station to eliminate from the waves transmitted therethrough, all frequencies corresponding to the frequencies of both control waves f_1 and f_2 generated at the west and east terminal stations, respectively, false operation of the transmitting and receiving control circuits by currents other than the control waves is prevented. The filter 36 in the receiving circuit RC at the west terminal station and the corresponding filter 36′ in the receiving station RC′ at the east terminal station are designed to eliminate frequencies corresponding to the control wave transmitted from the other terminal in order to prevent the control waves from being heard by the listener associated with the lines TL or TL′, respectively.

False operation of the several switches in the transmitting and receiving circuits at the two terminal stations by line noise or static may be prevented by proper adjustment of the sensitivity of the relay control devices and/or the relays controlled thereby at each station in well known manner. It may be desirable to provide some means other than decreasing the sensitivity of the receiving control devices and/or the relays controlled thereby, which, of course, tend to make the system more sluggish and unsatisfactory for high quality transmission, to prevent false operation of the switching devices by the static entering the receiving circuit along with the speech. The use of discriminating circuits of the invention such as illustrated in Fig. 1 or 2 for this purpose will greatly improve the operation of the system as a whole.

If the circuit of Fig. 1 is utilized for this purpose, the relays 40 and 44 at the west terminal would each be provided with two opposing windings; the selective circuit 51 would be replaced by two selective circuits corresponding to the circuits 8 and 11 of Fig. 1, having their inputs connected through a suitable amplifying device across the receiving circuit RC in front of the filter 6, and the relay-controlling device 52 would be replaced by two similar devices corresponding to the devices 7 and 10 of Fig. 1, the output of one of said devices being connected to one of the differential windings of each relay and the output of the other of said devices being connected to the other differential winding of each relay, and the inputs of the two devices being connected, respectively, to the outputs of the two selective circuits Each of the two selective circuits would be designed to pass one of two narrow frequency bands, one ranging from $f_2-\Delta$ to $f_2+\Delta$ and the other ranging from $f_2+\Delta$ to $f_2+3\Delta$ where Δ is a very small frequency range. If Δ is made sufficiently small, the power in each selected band due to the static currents will be substantially equal, and the static, therefore, will be effectively balanced out in the windings of the differential relays. The control wave f_2, however, will not be balanced out in the relay windings, since it is contained in one of the passed bands only. By utilizing three or more of the selective circuits and a corresponding number of the differentially wound relays connected in the manner shown in Fig. 2, the possibility of false operation by static may be made still more remote. A similar discriminating circuit operating in similar manner may be used at the east terminal station to insure operation of the switches 39′ and 43′ in response to the control waves f_1 while preventing false operation of the switches by the static.

Fig. 4 shows the circuit of the invention applied to the two-way radio telephone terminal of the type in which the transmitting circuit is normally disabled, such as is used in the present transAtlantic radio telephone system. It differs essentially from the circuit shown in Fig. 3 only in that an additional relay 53 is connected to the output of the wave-controlled, relay-controlling device 46 in parallel with the relays 12 and 47, the additional relay 53 operating in response to operation of the device 46 by the waves diverted into the control circuit 45 from the transmitting circuit TC to close the normally open switch 54 in the transmitting circuit TC between the point of connection of the control wave generator 49 thereto and the radio transmitter 31. In this circuit the normally disabled transmitting circuit makes it unnecessary to have the transmitting and receiving antennæ located at widely separated points to reduce transmission therebetween to a sufficiently low level as to produce no ill effects on the received speech or the wave-controlled receiving switching devices as would be required in the system of Fig. 3.

The use of an auxiliary control wave instead of the speech waves themselves for controlling the switching apparatus in a two-way signal transmission system as in the circuits of the invention shown in Figs. 3 and 4, constitutes a decided improvement from the standpoint of an increase in discrimination against static because of the smaller frequency band which is utilized for control. It is estimated that this discrimination would amount to as much as 20 decibels due to the use of the smaller frequency band, and that the discrimination against static would be increased by another 20 decibels by using at each terminal station, a receiving control such as shown in applicant's Figs. 1 and 2. In addition there is an appreciable gain due to the control currents being of much more nearly constant magnitude than is the speech current. These gains would seem to be sufficent to insure satisfactory operation even though the static power were considerably greater than the speech power. As the transmitting-control device 46 associated with the transmitting circuit TC at the west terminal station and the corresponding device at the east terminal station in the system of Fig. 3 or Fig. 4 receives only the speech and land line noise, it can be worked at greater sensitivity than the receiving side which is subject to static so that less transmitting delay is needed to be provided by the delay circuit 34 or 34′. This results in shorter hangover times and, therefore, shorter breaking times. The control current may be utilized for other purposes in addition to that of controlling the switching apparatus. For example, it may be utilized to indicate the transmission equivalent of the radio path if a meter with a suitable scale is utilized in the receiving control circuit 50 or 50′.

It is apparent that the principles of the invention may be applied to other circuits differing considerably from the circuits disclosed without departing from the spirit and scope of the invention. The invention is only to be limited in accordance with the appended claims.

What is claimed is:

1. A signal receiver subjected to combined waves including signal waves of energy characteristics similar to speech and interfering waves of substantially constant energy level over a definite frequency range, comprising means for subdividing the frequency band of the combination waves into a plurality of sub-bands within said definite frequency range, means for balancing said sub-bands against each other so as to effectively neutralize the energy therein due to said interfering waves, and means responsive to differences in the energy level in said sub-bands balanced against each other caused by the presence in one or more of a signal harmonic and the absence of a signal harmonic of equal power content in one or more of the other sub-bands, for distinguishing between said signal waves and said interfering waves.

2. A signal receiver subject to combined alternating current waves including signal waves of energy characteristic similar to speech and interfering waves of substantially constant energy level over a definite frequency range, comprising means for subdividing the frequency band of the received combined waves into three or more frequency sub-bands within said definite frequency range, three or more mechanical relays each having two opposing windings, means for rectifying each of the subdivided frequency bands, and for applying the rectified bands to the windings of said relays so that the several bands are balanced against each other in the relays, and receiving means responsive to a difference between the amplitude levels of the current in the two windings of any one of the relays.

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